

Town Belt Reserve Management Plan and Otago Harbour Reserve Management Plan review

Stage 2 submissions 21 August to 23 October

A submission from Mike Broughton, Dunedin Dark Skies Group

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Beverly-Begg Observatory

The Beverly-Begg Observatory is an historical astronomical observatory, situated in Robin Hood Park in the Belleknowes part of Dunedin's town belt. It was established in 1922 by the Dunedin Astronomical Society. This Observatory is used for education, public outreach, and research.

Summary

White, correlated colour temperature (CCT) c.a. 3,000 kelvin (K) LED streetlights in Ross Street and City Road have a continuous, broad light spectrum containing a large peak, 20 to 25% of blue light. White, blue-rich streetlights create a disproportionately high level of sky glow, interfering with stargazing and astronomy.

1. Replace all white 3,000 K LED streetlights in Ross Street and City Road with narrow band amber (0% blue light) \leq 2,200 K LED streetlights.
2. Prevent direct light in Ross Street and City Road streetlights from spilling into the Observatory and Robin Hood Park.
3. Prevent direct light emitted by vehicles from spilling into the Observatory and the park by erecting a screening fence along the western (Ross Street) park boundary.
4. Plant a shelter belt of native trees and shrubs on the western boundary, shielding the park from stray light, providing wildlife habitat and adding amenity value.
5. Deploy a reactive streetlighting control system with low luminous flux, (3 lux) brightening to 10 lux (current luminous flux) in the presence of vehicles and pedestrians, dimming to 3 lux when traffic has passed.
6. Turn streetlights off when traffic volume is low, turning on as traffic approaches then and off when it has passed.

Streetlighting history

Dunedin's streetlights have become progressively brighter and more widespread since they were introduced around the mid-19th century. Their hue has changed from predominantly orange and yellow to white.

Gas lamps illuminated Dunedin from the mid to late 19th century. Gas light is like candlelight is warm, c.a. CCT 2,000 kelvin and is dim. The night sky was pristine, and wildlife abounded; there was little light pollution.

Incandescent carbon filament later tungsten filament electric streetlights were introduced in the late 19th and early 20th century. These lamps converted about 5 to 10% of their power, c.a. 100 watts into light. Tungsten filament incandescent streetlamps were like those still used in homes, CCT 2,700 K. Their warm-white light was like the continuous spectrum of the rising and

setting Sun, dominated by red light and diminished in blue light. Incandescent streetlamps were sparse and therefore, their impact on the night sky was limited.

From the early 1970's suburban streetlights with incandescent lamps were replaced with linear cool-white, CCT c.a. 4,000 K fluorescent lamps. However, they were comparatively dim. Arterial routes were lit with low pressure sodium (LPS), followed by high-pressure sodium (HPS). Yellow LPS and orange-yellow HPS have narrow, discontinuous light spectrums, with spectral power distributions (SPD) centred on the sodium spectral D line, with nil (LPS) to about 10% blue light (HPS). HPS was used in streetlighting throughout Dunedin. It is still used on the southern motorway.

Amber LPS and HPS lamps are less light polluting than white LED lamps. The teardrop shape of the glass lens in the luminaire (lamp fitting) used in LPS and HPS streetlights significantly increased light pollution, imparting an orange glow on the night sky. An advantage was that their yellow-orange light could be filtered out for astronomical purposes.

This situation changed dramatically in 2016 with the introduction of white light emitting diode (LED)s. White LEDs produce a broad continuous light spectrum, which is dominated by a strong blue light peak. Shorter wavelength blue light creates disproportionately far more light pollution seen as sky glow due to Rayleigh scattering than does longer wavelength yellow, orange (amber) and least of all, red light.

The blue light content of a white LED is proportional to its colour temperature. A 4,000 K white LED streetlight contains c.a. 30% blue light. A 3,000 K LED streetlight contains c.a. 20% blue light, and a 2,200-kelvin amber LED streetlight contains c.a.10% blue light. Thus, the amber 2,200 K LED streetlights on the Otago Peninsula and in coastal settlements are less obtrusive than white LEDs.

Blue-rich, broad-spectrum, and bright (c.a. 10 lux at ground level) white 3,000 K and cool-white 4,000 K LED streetlights are undesirable in the vicinity of astronomical observatories, such as the Beverly-Begg observatory.

Narrow-band amber (NBALED) streetlights are analogous to LPS (considered the gold standard for astronomical observatories) because they emit no blue light. NBALED lamps are the modern-day lighting of choice because they have the lowest impact on astronomical observations. John Hearnshaw is Professor Emeritus of Astronomy and Physics, University of Canterbury and a former director of Mt John Observatory in Tekapo discusses these topics in his New Zealand Dark Sky Handbook, which is available in the Dunedin public library. A copy was given to the DCC.

Screening vehicle lights

Erecting a fence along the western park boundary would block light emitted by vehicles travelling down Ross Street. Today's modern vehicles are equipped with extremely bright, cool-white, blue-rich, high Intensity discharge (HID) or LED headlamps; they bedazzle onlookers creating disability glare and it distracts their attention. They rapidly destroy star gazer's dark-adapted night vision, which takes 30 minutes to regain, disrupts their circadian rhythms (biological clocks) and quickly inhibits the secretion of essential hormones.

Plantings of native evergreen trees and shrubs along the western park boundary would extend wildlife habitat, provide additional screening, and increase the amenity value of the Observatory, park and the town belt.

Recommendations for Robin Hood Park and the Beverly Begg Observatory

Streetlights will have fully-shielded, downward-pointing, amber-coloured LEDs with CCT \leq 2,200 K and emit no (0%) blue light. They would employ a reactive lighting control system, have low luminous flux, e.g. 3 lux, brightening in the presence of traffic, dropping back to the lower light level when it has passed.

Luminaires shall spill no light at or above horizontal. LED arrays will be recessed in the luminaire or lie horizontal, analogous to the shielded HPS streetlights in the southern motorway SH1 in Caversham valley. Streetlights in line of sight would have additional shielding preventing direct light spilling into the Observatory and park.

Footpaths within Robin Hood Park and the adjacent golf course may be lit with low intensity, warm 2,200 K fully-shielded, downward-pointing bollards or using solar-powered reflectorized red or amber LEDs embedded in the footpath, as per the reflective amber LED lighting at the northern end of Robin Hood Park. Red or amber footpath lighting should be installed on the south side of the Robin Hood park.

Erect signage at the park's entrances advising visitors to follow the red (or amber) navigation lighting and to restrict their use of personal lights to not impinge on stargazing and astronomical observations.

Lighting safety

Amber or yellow streetlights are safe. There is no compelling evidence that amber LEDs are less safe than white LEDs. Warm-coloured lights do not present a navigation issue for pedestrians and motorists as illustrated by the long history of using low intensity yellow or amber streetlighting in Dunedin. Pedestrians and vehicles safely travel along coastal roads on the Otago Peninsula lit by amber (c.a.10% blue light) 2,200 K LED streetlights. Amber streetlights are found in coastal villages from Long beach, Warrington, Waitati, Waikouaiti and Karitane. Purakaunui has a solitary HPS streetlight.

Decorative unshielded HPS streetlights illuminate Macandrew Bay, Port Calmers, and parts of Princess Street. HPS also illuminates the southern motorway and Dunedin's railway yards. A big advantage of HPS and LPS over LED is they produce less glare, so are less distracting and much easier on eyes. HPS and LPS lamps are energy efficient with LPS producing up to 200 lumens per watt, comparing favourably with LED.

Aramoana and Harwood have eschewed streetlights, demonstrating that their communities have no need for them; research shows that the absence of streetlights tends to lessen antisocial behaviour and crime. The cloak of darkness shields residents.

Town belt and West harbour

West harbour is home to native or exotic mammals, amphibians, reptiles, birds, insects and other invertebrates. Fully shielded warm-coloured amber 2,200 K LED (low blue light) streetlights should illuminate the town belt and settlements in West harbour, thereby matching the wildlife-friendly streetlighting on the peninsula.

Life evolved without streetlights. Humans and wildlife haven't adapted to cope with bright lights at night, especially if they emit blue-rich white light. Wildlife and citizens living in the city seldom

or never experience true darkness. This has adverse consequences for our health and wellbeing, and for animal welfare.

Nocturnal and crepuscular (active at dawn and dusk) wildlife is susceptible to adverse effects from artificial light at night (ALAN). A typical Dunedin LED streetlight appears 200 times brighter than the full moon (c.a. 0.05 lux). Moonshine on average is much less than 0.05 lux as the Moon waxes and wanes as it revolves around the Earth.

Dunedin's white LED streetlights may be exerting a potent and detrimental influence upon wildlife. Bright, broad-spectrum, white light emitted by LEDs and by other sources like Metal Halide is particularly harmful to ecosystems and their communities of plants and animals. Research in New Zealand and internationally has demonstrated that ALAN harms many or all aspects of animals' life cycles, disrupting their biological clocks, physiology, navigational, reproductive, and foraging behaviour. Bright lights also disrupt the normal growth patterns of plants. Persistent exposure to ALAN alters senescence (leaf fall) in deciduous plants and it make their leaves tougher for animals to digest.

Dunedin is perpetually enveloped by a veiling haze of light pollution, and it is obscuring the stars, Matariki, Magellanic Clouds and the Milky Way. This may disrupt navigation by wildlife such as insects and migratory sea birds like the Royal Albatross.

Sky glow is produced by ALAN scattering off water molecules and fine particles (dust and air pollution) in the atmosphere and it is amplified six-fold (and as much as ten-fold) by reflecting off cloudy skies according to Professor Margaret Stanley, Auckland University. Dunedin is predominantly cloudy, so this is a cogent reason to limit ALAN.

Water ways

The Otago harbour cycleway is inappropriately illuminated. It should not be lit at night unless it is being used by travellers. Dead mayflies, tens of thousands were piled high on a walking bridge by the Manawatu River, when white LED lights were installed on it.

ALAN is harmful to aquatic organisms, including zooplankton and phytoplankton, fish, amphibians, seabirds, marine mammals and aquatic insects. Never direct or spill ALAN into natural waterways. Avoid or minimize ALAN in or near lakes, ponds, rivers, streams, harbours, wetlands, estuaries and the open sea.

Dr Michelle Greenwood from NIWA demonstrated that ALAN from streetlights is detrimental to flying aquatic insects in Christchurch. Michelle's team reported that warmer i.e. lower CCT LED streetlights were less attractive, catching fewer flying aquatic insects than cooler, higher CCT LED streetlights.

Michelle's research is a clarion call to cease the indiscriminate use of ALAN in Dunedin. More than half of our native, mostly endemic i.e. unique insect species may be endangered, and some are facing extinction. A substantial proportion of native insects (perhaps the majority) are nocturnal; thus, they are especially vulnerable.

Responsible Outdoor Lighting

Responsible outdoor lighting only illuminates areas intended for use by people and vehicles, is low intensity and warm as practicable. It minimises blue light emissions and is switched on only when needed.

A sensor can be employed. Low-intensity LED lighting brightens in the presence of people or vehicles, reverting to the lower level when they pass. At a certain time in the night, such as late evening when traffic volumes are low, lighting switches off, reactivating on approach.

A good illustration of a reactive lighting system controlled by sensors is operated by Blue Penguins Pukekura at Pilots beach on the Otago Peninsula. The pathway starting at the carpark is illuminated for tourists to walk down to the observing platform near the beach. Individual pathway lights are dim, brighten as people approach, dimming again after they pass.

Red light is possibly the least disruptive light to wildlife, and it conserves human night vision. Red lights are embedded in the floor of the little blue penguin viewing platform. A food cart is illuminated exclusively by red light. Unfortunately, white light is shone on the penguins for the benefit of tourists, but it is only for an hour or so, and revenue is used to help the birds to breed. Nevertheless, these bright white lights should be considerably warmer and shielded, not spilling over the beach and harbour, impacting vulnerable wildlife; they are offending in an otherwise dark locale at Taiaroa Head.

Five Principles for Responsible Outdoor Lighting

Dark Sky International (formerly called the International Dark Sky Association) advises light where you need it, when you need it, in the amount needed, and no more. If light is deemed useful and necessary, follow these guidelines to prevent, or when that's not possible, minimize light pollution.

Outdoor lighting should be:

1. Useful
2. Targeted
3. Low level
4. Controlled
5. Warm coloured

1. Useful

Use light only if it is needed

All light should have a clear purpose. Consider how the use of light will impact the area, including wildlife and their habitats.

2. Targeted

Direct light so it falls only where it is needed

Use shielding and careful aiming to target the direction of the light beam so that it points downward and does not spill beyond where it is needed.

3. Low level

Light should be no brighter than necessary

Use the lowest light level required. Be mindful of surface conditions, as some surfaces may reflect more light into the night sky than intended.

4. Controlled

Use light only when it is needed

Use controls such as timers or motion detectors to ensure that light is available when it is needed, dimmed when possible, and turned off when not needed.

5. Warm-coloured

Use warmer-colour lights where possible

Limit the amount of shorter wavelength (blue-violet) light to the least amount needed.

Wildlife

Wildlife populations are plummeting to the extent that we are witnessing the 6th global mass extinction of life. Human activities extensively exploit the World's natural resources, and they heavily pollute the environment. Climate change, habitat destruction like deforestation, invasive species, urbanization, wars, intensive agriculture, agrochemicals such as synthetic fertilizers, pesticides including insecticides, herbicides and fungicides, micro-plastics and nano-plastics, persistent non-biodegradable chemicals "forever chemicals", adversely affecting land, sea, and atmosphere. Space and the upper atmosphere too is being polluted by myriad communication satellites and their launch vehicles. Sound, electromagnetic and significantly light pollution are but some of the reasons cited for this existential crisis.

Insect populations are rapidly declining globally and many species are at risk of extinction; scientists call this phenomenon the "insect apocalypse an ecological Armageddon." Insect population decline has multiple causes as referred to above.

Light pollution is causing significant losses of nocturnal insects that may comprise the majority (c.a. 60%) of all insect species. ALAN is impacting on insects in Aotearoa, observed anecdotally, which is now supported by research.

Conclusion

Ōtepoti Dunedin, wildlife capital of Aotearoa New Zealand may be inadvertently failing in its duty of care to protect insects and invertebrates, especially at night. It may also be failing crepuscular and nocturnal wildlife such as Little Blue Penguins, other sea birds, and Ruru.

It's failing to uphold and respect Māori (and Pakeha) cultural identity by obscuring the Milky Way including Puaka and Matariki, thus impinging on fundamental human rights.

The harbour and town belt can show citizens the way forward in relation to the night. The default state of **ALL** outdoor lights, private and public, including streets, footpaths and walkways ought to be **OFF**, turned on when deemed strictly necessary, not lighting up the night irrespective of traffic.

Use ALAN sparingly. Red and amber *sans* blue light outdoor lighting is regarded as the least disturbing to wildlife, but this isn't guaranteed, the overwhelming preference is for **NO** artificial lighting in areas where wildlife dwell.

Encourage people to rely upon dark-adapted night vision when out walking. This may reduce disturbance to crepuscular, nocturnal, and diurnal wildlife.

Use red and amber lights in preference to white light at night. Encourage perambulating people to use red light; this is readily available in torches and on various modes of transport. Red light

preserves night vision, and it may limit disruption to circadian rhythms and essential hormones like melatonin and human growth hormone that are secreted only in darkness.

Protecting our precious wildlife ought to be around the clock because we live on a rotating planet. Dunedin's civic authorities like the ORC and DCC appear to have focused conservation efforts upon the daytime as judged by the enormous pall of deadly light pollution gracing our night skies. Evidently, they don't consider the night to be a crucial and critically endangered temporal ecosystem. Ōtepoti Dunedin and throughout New Zealand just like the rest of the world is rapidly losing the night to encroaching light pollution.

Give our precious wildlife back the night because our future depends on it!

